Geophysical Research Abstracts, Vol. 7, 02551, 2005
SRef-ID: 1607-7962/gra/EGU05-A-02551

Long-term memory of the climate system: Data, simulations and concept

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Power-law scaling of near surface air temperature fluctuations and its geographical distribution is analysed in 100 year observations and a 1000 year simulation of the present-day climate with a complex atmosphere-ocean model. In observations and simulations detrended fluctuation analysis (DFA) leads to the scaling exponent $\alpha \approx 1$ ($1/f$ or flicker-noise) over the oceans, $\alpha \approx 0.5$ or white noise over the inner continents, and $\alpha \approx 0.65$ in transition regions (spectrum $S(f) \sim f^{-\beta}$, $\beta = 2\alpha - 1$). Scaling up to decades is demonstrated in observations and coupled atmosphere-ocean models with complex and mixed-layer oceans. Only with the complex ocean model the simulated power-laws extend up to centuries. A diffusive two-layer vertical energy balance model of the ocean appears to provide a simple explanation for the physics underlying the long-term memory and $1/f$ noise caused by the complex ocean circulation.